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Original Article

Regional anaesthesia practice for arteriovenous fistula formation surgery

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Summary

We conducted a survey and semi-structured qualitative interviews to investigate current anaesthetic practice for arteriovenous fistula formation surgery in the UK. Responses were received from 39 out of 59 vascular centres where arteriovenous access surgery is performed, a response rate of 66%. Thirty-five centres reported routine use of brachial plexus blocks, but variation in anaesthetic skill-mix and practice were observed. Interviews were conducted with 19 clinicians from 10 NHS Trusts including anaesthetists, vascular access and renal nurses, surgeons and nephrologists. Thematic analysis identified five key findings: (1) current anaesthetic practice showed that centres could be classified as 'regional anaesthesia dominant' or 'local anaesthesia/mixed'; (2) decision making around mode of anaesthesia highlighted the key role of surgeons as frontline decision makers across both centre types; (3) perceived barriers and facilitators of regional block use included clinicians' beliefs and preferences, resource considerations and patients' treatment preferences; (4) anaesthetists' preference for supraclavicular blocks emerged, alongside acknowledgement of varied practice; (5) there was widespread support for a future randomised controlled trial, although clinician equipoise issues and logistical/resource-related concerns were viewed as potential challenges. The use of regional anaesthesia for arteriovenous fistula formation in the UK is varied and influenced by a multitude of factors. Despite the availability of anaesthetists capable of performing regional blocks, there are other limiting factors that influence the routine use of this technique. The study also highlighted the perceived need for a large multicentre, randomised controlled trial to provide an evidence base to inform current practice.

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Introduction

Guidelines from the UK Renal Association and European Society for Vascular Surgery recommend an autogenous arteriovenous (AV) fistula as the primary option for vascular

access for haemodialysis [1, 2]. A well-functioning AV fistula is associated with the lowest health and economic burden for patients on haemodialysis [3]. However, AV fistula failure rate is very high at around 50% at one year [4–7].

It has been postulated that since regional anaesthesia (RA) nerve blocks may increase vasodilation and blood flow during AV fistula creation, they improve fistula success [8, 9]. A systematic review and meta-analysis from four single-centre randomised controlled trials (RCT) showed that the use of RA nerve blocks for AV fistula surgery was associated with improved AV fistula patency compared with local anaesthesia (LA) [10]. Despite the promising results, all the included studies had limitations. They reported surrogate outcomes (patency or flow rates) and lacked longer term follow-up or any cost effectiveness analysis. Administration of RA blocks requires the presence of an appropriately-trained anaesthetist and takes longer than LA [11]. Although the available evidence points towards RA being beneficial, only a large multicentre RCT can provide enough evidence with which to change guidelines and practice. This recently prompted a commissioned call from the National Institute for Health Research Health Technology Assessment Programme to fund a trial to investigate the clinical and cost effectiveness of RA vs. LA for primary AV fistula formation surgery [12]. UK Renal Association guidelines on vascular access for haemodialysis do not include recommendations on anaesthetic technique, and the recent European Society for Vascular Surgery guidelines recommend that RA should be considered in preference to LA based on conflicting, Level B evidence [1, 2].

Data on the mode of anaesthesia used for AV fistula formation in the UK are sparse and practice is believed to vary significantly across UK hospitals. There is also limited understanding of the reasons underpinning current practice. Qualitative research methods are integral to understanding practice in complex clinical environments and have been used to inform prospective clinical trial design to enhance relevance and feasibility [13, 14]. The aim of this study was to conduct a targeted survey followed by in-depth qualitative interviews to investigate current anaesthesia practice for AV fistula formation surgery in the UK.

Methods

We undertook a survey and qualitative study in parallel [15]. An online survey for anaesthetists collected descriptive information about current RA practice for AV fistula formation surgery. Completion of the survey was taken as a proxy for informed consent. Qualitative interviews sought to explore anaesthesia practice in greater depth and uncover insights not captured in the survey. Ethical approval for the qualitative work was granted by the University of Bristol Faculty of Health Sciences Research Ethics Committee. All interview participants provided oral or written consent. Data integration occurred during the interpretation phase after both quantitative and qualitative data analyses [15].

We designed an electronic survey consisting of a series of questions to identify baseline characteristics; anaesthetic options currently used for AV fistula surgery; competence and practice with regard to brachial plexus blocks; hospital logistics influencing anaesthetic practice and interest; and perceived barriers, for participating in a randomised controlled trial to test the clinical and cost effectiveness of RA vs. LA for AV fistula surgery (Box 1 and see Supporting Information, Appendix S1). The initial survey questions were developed with the Bristol University Clinical Trials and Evaluation Unit, with input from experienced vascular access anaesthetists as well as trialists, nephrologists, vascular surgeons, a renal nurse and patients.

The survey was piloted by seven vascular anaesthetists from four vascular centres in the UK. The pilot was used to refine the questions and estimate the completion time. The final survey was published on SurveyMonkey® and sent via email to vascular centres where renal access surgery is performed. The denominator of 59 was determined as follows: centres were identified from a recent organisational audit performed by the National Vascular Registry where 59 vascular units confirmed that they performed AV fistula surgery [16]. We were able to identify and approach vascular anaesthetists at 53 out of the 59 to complete one survey response on behalf of each centre. The survey was open for 2 months between June and August 2019. No formal sample size calculation was performed as the survey was designed to include all hospitals where AV fistula surgery is performed and to elicit one response from each hospital.

Qualitative semi-structured interviews were used to explore current practice and professionals' views on anaesthesia practice for AV fistula formation. Interviews enabled participants to raise new considerations that had not been anticipated by the research team and offer responses that could not be captured in survey format.

A subset of anaesthetists who completed the survey was selected to take part in an in-depth interview, in order to compare and contrast accounts of current practice in different centres. Non-anaesthetist interview participants were selected with the intention of building a sample comprising a range of professionals involved in the clinical pathway leading up to AV fistula surgery. Individuals known to the research group were initially approached, followed by snowball sampling techniques, where respondents recommended other appropriate individuals in line with the purposeful sampling criteria. Sampling was also driven through intentions to explore emerging insights in greater depth with sub-groups of professionals. Data collection was driven by the intention of reaching saturation, defined as the point where further interviews did not meaningfully develop

Box 1 Factors included in survey**Hospital-specific logistics**

- Approximate number of primary arteriovenous fistula procedures performed per year
- Number of surgeons and anaesthetists regularly performing arteriovenous fistula procedures
- Modes of anaesthesia offered (local/regional/general)
- Proportion of vascular access lists ring fenced for local anaesthesia by surgeon only
- Presence of established pathways for vascular access patients
- Physical location in which regional blocks are performed

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- Anaesthetic department skill-mix for brachial plexus blocks
- Availability of 'block anaesthetists'
- Specific blocks used for arteriovenous fistula surgery at radial and brachial sites
- Method of proceeding if brachial plexus block insufficient
- If brachial plexus blocks seldom performed, reasons why

Other

- Interest in a prospective randomised trial comparing brachial plexus block and local anaesthesia
- Additional free text comments

our understanding of current practice and stakeholders' perceived relevance and feasibility of a future RCT.

Individuals approached for interview were sent a study information sheet and consent form in advance. Interviews were informed by a topic guide (see also Supporting Information, Appendix S2) devised to ensure questions were sufficiently appropriate for the range of professionals we intended to interview. Telephone interviews took place between May and November 2019 and were recorded.

Survey data were analysed using RStudio (Version 1.1.442; RStudio Team, 2016). Qualitative interviews were transcribed and analysed thematically, using constant comparison methods [17]. This involved line–line coding and iteratively organising related codes into 'themes'. The themes and code hierarchies evolved with concurrent data collection

and analysis. One researcher (CW) led the analysis, with a second researcher (LR) independently coding the interviews to promote reliability. A descriptive report of key themes emerging from the interviews was produced partway through data collection and refined, and then discussed with the wider research team to inform further data collection.

Results

Survey responses were received from 39 out of the 59 centres, giving a response rate of 66.1%. The majority of centres offered LA, RA and general anaesthesia (GA) for these procedures: LA was available at 38/39 centres, with RA and GA each available at 37/39 centres. Only 10% (4/39) centres reported that more than 50% of their AV fistula access lists are allocated for LA by surgeon only, with no anaesthetist allocated to the list. Thirty-one centres (80%) reported an established pathway for patients undergoing vascular access surgery for haemodialysis. In centres performing brachial plexus blocks, the blocks are performed in the anaesthetic room in 91.7% centres. The skill-mix of anaesthetists for providing brachial plexus blocks varied across centres and 7/39 (17.9%) reported less than half of anaesthetists who regularly provide cover for AV fistula access lists are competent in performing brachial plexus blocks. Most centres (33/39, 85%) reported access to an available 'block anaesthetist' who could assist and provide a brachial plexus block if required. Thirty-six percent (14/39) of centres reported that brachial plexus blocks are used for less than 10% of patients undergoing AV fistula access surgery. The cited reasons were 'surgeon preference' (6); 'too time consuming' (3); 'no regular anaesthetist available to perform a block' (3); 'lack of facilities' (1) and 'no robust evidence to support... advantages' (1) (Table 1).

The survey data indicated considerable variation in the preferred approaches for brachial plexus blocks at different centres. When asked specifically about supraclavicular blocks, 14/35 centres (40%) reported using this approach for the majority of radial AV fistula formation surgery. For brachial AV fistulas, 18/35 centres (51%) used supraclavicular blocks for most patients. Alternative approaches were described by 29 centres, most commonly axillary blocks (26/29). In patients where RA block provides insufficient anaesthesia, the most common way of proceeding was supplemental LA infiltration at the operating site, followed by conversion to GA (Table 2).

Interviews were conducted with 19 clinicians from 10 NHS Trusts ('centres') that perform vascular access surgery. The centres included large regional transplant centres and small district general hospitals across England and Wales. The sample of informants comprised seven anaesthetists (from six centres), seven vascular access and renal nurses

(seven centres), three surgeons (one centre) and two nephrologists (two centres). Interviews lasted between 35 min and 1 h 20 min.

Five key themes and 11 subthemes (Table 3) emerged from the analysis. Illustrative quotes have been used to support the findings throughout (see also Supporting Information, Appendix S3).

Theme 1: current anaesthesia practice for AV fistula formation

Informants suggested there were trends in dominant practices within each centre. Based on this, the qualitative sample of 10 centres was characterised as either 'RA dominant' ($n = 3$), where 70–80% of cases were estimated to be undertaken with RA, or 'LA/mixed' ($n = 7$), where LA was estimated to be used in over 50% of cases.

In the LA/mixed centres, informants tended to report the de facto use of LA for straightforward cases, with GA considered as the next option if LA was deemed inappropriate (see also Supporting Information, Appendix S3 (T1, quote 1)). In some of these centres, RA would reportedly feature more in the decision making if patients were being considered for GA (see also Supporting Information, Appendix S3 (T1, quote 2)). RA was often described as a consideration for patients who were clinically unsuitable for GA due to comorbidities (see also Supporting Information, Appendix S3 (T1, quotes 3–5)). In RA-dominant centres, LA was used for radiocephalic cases or the first radiocephalic case on the list. GA use was infrequent and restricted to patients who were highly anxious or those with learning difficulties.

Table 1 Hospital-specific logistics.

Question	Response		
Does your hospital have ring fenced lists for local anaesthesia by surgeon only (no anaesthetist present)?	Yes 20 (51%)	No 19 (49%)	
If yes, what proportion of vascular access lists do these represent?	≤50% 16 (80%)	>50% 4 (20%)	
Is there an established pathway for haemodialysis vascular access patients?	Yes 31 (80%)	No 2 (5%)	Do not know 6 (15%)
In what location are brachial plexus blocks for these procedures performed?	Anaesthetic room 32 (91%)	Operating theatre 3 (9%)	

Table 2 Reported approaches to brachial plexus blocks in 35 centres routinely using regional anaesthesia for arteriovenous (AV) fistula formation surgery.

	Percentage of blocks done via supraclavicular approach				
Fistula site	0%	<50%	51–70%	71–90%	> 90%
Radial AV fistula at wrist	6 (17%)	15 (43%)	4 (11%)	5 (14%)	5 (14%)
Brachial AV fistula at elbow	3 (9%)	14 (40%)	5 (14%)	5 (14%)	8 (23%)
What other approaches to brachial plexus blocks are used in your hospital?					
Axillary	26 (74%)				
Infraclavicular	9 (26%)				
Other ^a	4 (11%)				
What is the most common way of proceeding when a regional anaesthetic block is not providing sufficient anaesthesia? ^b					
Supplemental local anaesthetic infiltration	27 (77%)				
Top-up/additional block	6 (17%)				
Sedation	8 (23%)				
General anaesthesia	14 (40%)				

AV; arteriovenous.

^aOther: combined supraclavicular and axillary; interscalene; superior trunk block; pectoral nerve block (PECS-2).

^bTotal responses exceeds number of centres as some reported multiple options or different options for different brachial plexus blocks.

Table 3 List of key themes and subthemes from thematic analysis of qualitative interview data.

Themes	Sub-themes
Theme 1: perceptions of current anaesthesia practice for AV fistula formation	<p>A: 'LA/mixed centres'</p> <ul style="list-style-type: none"> De facto use of LA use for simple fistulae GA vs. RA for non-LA cases RA for comorbid renal patients unsuitable for GA <p>B: 'RA dominant centres'</p> <ul style="list-style-type: none"> Most simple fistulae done under RA GA use low or rare
Theme 2: perceptions of decision making around the mode of anaesthesia for AV fistula formation	<p>A: Surgeons' role in decision making around the mode of anaesthesia for AVF formation</p> <ul style="list-style-type: none"> Surgeons as frontline decision makers <p>B: Anaesthetists' involvement in the pathway and anaesthesia decision making</p> <ul style="list-style-type: none"> Anaesthetists' varied involvement in decision making for GA/RA cases
Theme 3: perceptions of barriers and facilitators of regional block use	<p>A: Clinician beliefs and preferences</p> <ul style="list-style-type: none"> Surgeons' preference for LA Surgeons' positive experiences of RA Anaesthetists as agents for change <p>B: Resource considerations</p> <ul style="list-style-type: none"> Cost Lack of resources (space, 'block anaesthetists') Impact on theatre efficiency <p>C: Patients' treatment preferences for RA or GA</p> <ul style="list-style-type: none"> Anaesthetists discussions of patients' GA/RA preferences Patient discomfort and anxiety with LA (especially re-operations) Growing awareness and preferences for 'awake surgery'
Theme 4: Anaesthetists' preferences for brachial plexus block	<p>A: Anaesthetist competence and preference for supraclavicular blocks</p> <ul style="list-style-type: none"> Perceptions of completeness/effectiveness and speed Dual practice: supraclavicular blocks for elbow or above fistula; forearm and wrist (axillary) <p>B: Preference for axillary block for renal patients (outlier)</p> <ul style="list-style-type: none"> Axillary sufficient for most fistulae Concern about anaesthetising phrenic nerve
Theme 5: Perspectives on a future RCT	<p>A: Perceived need and support for a future RCT</p> <ul style="list-style-type: none"> Concern for fistulae failure rate Desire to improve functional fistulae rates Need for evidence to inform current practice Desire to improve patient experience of AVF surgery <p>B: Perceived barriers to a future RCT</p> <ul style="list-style-type: none"> Clinician (especially surgeon) preferences for LA Problems with equipoise in RA-dominant centres Lack of resources to deliver RA (space to deliver RA, availability of 'block anaesthetist') Logistics to organise theatre lists and randomisation close to surgery Impact of RCT on theatre list efficiency/number of procedures Increased cost of fistulae done under RA Patient preferences for RA/GA (especially for re-dos) Complex pathways involving teams of clinicians

AV, arteriovenous; LA, local anaesthesia; RA, regional anaesthesia; GA, general anaesthesia; RCT, randomised controlled trial.

Theme 2: decision making around the mode of anaesthesia for AV fistula formation

Decision making around mode of anaesthesia was reportedly devolved to the clinician–patient level, with surgeons taking a lead role. All respondents were asked if they were aware of any Trust policies or guidelines that shaped local decision making, though none were reported.

Surgeons were widely regarded as front-line decision makers in selecting anaesthesia modality, irrespective of

centre type (see also Supporting Information, Appendix S3, (T2, quotes 1 and 2)). Most accounts indicated anaesthetists were not routinely involved in the vascular access pathway until the day of surgery, unless patients had been flagged by the surgeon as particularly high risk (see also Supporting Information, Appendix S3 (T2, quote 6)). Informants from some centres reported surgeons' tendencies to list patients specifically for RA or GA. There were mixed views around how well this worked in practice; whereas one anaesthetist felt their

surgical team were adept at these decisions (see also Supporting Information, Appendix S3, (T2, quote 7)), others felt earlier anaesthetic involvement could be beneficial (see also Supporting Information, Appendix S3, (T2, quote 8)). Several anaesthetists reported how it could be challenging to manage patients' expectations, if their views on preferred anaesthesia modality contradicted what patients had been told beforehand (see also Supporting Information, Appendix S3, (T2, quote 9)). Some anaesthetists did report an active role in decision making between GA/RA earlier in the pathway, in collaboration with the surgeon (see also Supporting Information, Appendix S3 (T2, quote 10)).

Theme 3: barriers and facilitators of regional block use

Interviews explored informants' perspectives on the reasons underpinning current RA provision (or lack thereof), leading to accounts of perceived barriers and facilitators to RA use across three recurring subthemes.

In the LA/mixed centres, informants often discussed surgeons having a preference for LA by default, based on satisfaction with outcomes, as well as increased ease and efficiency (e.g. see Supporting Information, Appendix S3 (T3, quote 1)). These were key considerations, given the pressures of working through waiting lists to meet Trust targets. Two out of the three RA-dominant centres performed RA by default, which was rationalised by informants on the basis of perceived practical and clinical benefits that made surgery easier and led to the technical formation of better-quality fistulae (see also Supporting Information, Appendix S3 (T3, quote 2 and 3)). The remaining centre had transitioned towards RA, a change reportedly instigated by anaesthetists' engagement with new trial evidence which, in turn, became standard practice through positive surgical perceptions (see also Supporting Information, Appendix S3 (T2, quote 4)). The role of anaesthetists as agents for change was also apparent in other respondents' accounts of practices shifting (see also Supporting Information, Appendix S3 (T2, quotes 5 and 6)).

In alignment with survey findings, interview informants holding a range of roles often referred to lack of facilities and resources as obstacles to more widespread RA use. There was a tendency for professionals from LA/mixed centres to highlight the barriers to increasing RA, including personnel, logistics and financial considerations (see also Supporting Information, Appendix S3 (T3, quotes 7-9)). In contrast, RA-dominant centres did not report local issues around resource use. One consultant noted improved regional block list efficiency when supported to manage theatre and anaesthetic room patients simultaneously (see

also Supporting Information, Appendix S3 (T3, quote 10), although another described a negative impact on 'turnaround time' due to space issues (see also Supporting Information, Appendix S3 (T3, quote 11)).

Clinicians from a range of specialities recognised the importance of patient preferences in shaping practices. Anaesthetists, in particular, commented on a tendency to discuss options with patients (see also Supporting Information, Appendix S3, (T3, quote 12)). Key factors thought to influence shifts towards RA included patient discomfort and anxiety undergoing LA (particularly for re-operations) and some having preference to avoid GA on hearing about other patients' positive experiences (see also Supporting Information, Appendix S3 (T3, quotes 13 and 14)).

Theme 4: anaesthetists' preferences for brachial plexus blocks

Overall, anaesthetists acknowledged that their practices were driven by personal skill, experience and preferences, and recognised that this could be different to their peers (see also Supporting Information, Appendix S3 (T4, quote 1)). Most favoured the use of supraclavicular blocks, on the basis of speed of onset and perceptions that these provided a more 'complete' arm block (see also Supporting Information, Appendix S3 (T4, quote 2)). Additional factors included the location of the fistula and patient comorbidities (see also Supporting Information, Appendix S3, T4, quotes 3 and 4).

Theme 5: Relevance and feasibility of a randomised controlled trial

There was unanimous support for a RCT amongst those interviewed, prompted by professionals' reported concerns about fistulae failure and their keenness to improve patency rates (see also Supporting Information, Appendix S3 (T5, quotes 1-2)). Even individuals who were self-professed advocates for RA recognised the need for reliable comparative evidence to inform widespread practice (see also Supporting Information, Appendix S3 (T5, quote 3)).

Although supportive of a future trial, informants anticipated potential challenges in relation to recruitment and intervention delivery. The most dominant anticipated barriers were logistical and organisational, particularly the resource implications of accommodating RA patients into time-sensitive theatre lists and the reported lack of skilled anaesthetists and space (see also Supporting Information, Appendix S3 (T5, quotes 4 and 5)). Recruitment issues were predicted to arise from a lack of individual equipoise, based on professionals' preferences for either LA or RA. A unique issue to arise from the qualitative interviews is related to the

potential complexity and variety of the clinical pathway. The importance of ensuring team cohesion and broad awareness of the trial was highlighted (see also Supporting Information, Appendix S3 (T5, quote 6)). Loss of theatre efficiency and the potential disruption caused by randomising as close to intervention delivery as possible were cited as factors which could potentially impact support for a trial (see also Supporting Information, Appendix S3 (T4, quotes 7 and 8)).

Discussion

The results of this study show that anaesthesia practice for AV fistula formation surgery across 39 vascular centres in the UK is varied and influenced by a multitude of factors.

Our survey demonstrated significant variation in the preferred approach for brachial plexus block. Although a previous RCT [11] used mainly supraclavicular blocks as the intervention, the results from this survey show that the majority of cases are performed using other techniques, such as axillary, with notable variation in the blocks used across centres. Furthermore, five centres confirmed they already consider brachial plexus blocks superior, whereas 14 out of 39 centres perform brachial plexus blocks for < 10% of AV fistula formation surgery. Barriers to using brachial plexus block over LA, as indicated by survey and qualitative findings, included surgeon preference, time constraints and lack of anaesthetists to perform the block. The qualitative interviews built on this by showing how shifts towards RA appear to be facilitated by perceptions of improved outcomes, with anaesthetists often being recognised as the agents for this change. The range of factors identified as shaping choice of anaesthesia modality demonstrates the complexity of anaesthesia as an intervention and that the choice of mode of anaesthesia is determined by several interlinking factors that include not just the anaesthetist, but also the patient and surgeon. This concurs with a recently published qualitative study of clinician and patient perspectives on the mode of anaesthesia by Dooley et al., which also demonstrated that decisions about the mode of anaesthesia depend upon several interlinking factors, including expertise, preference, habit, practicalities and norms [18]. This also showed variation in practice in choosing modes of anaesthesia and significant uncertainty regarding the effects of different anaesthesia types on post-operative outcomes [18].

The qualitative interviews highlighted the multi-specialty care of these patients (renal, surgical and anaesthesia), and centre by centre variations in the timing and nature of how these professionals interact with patients in the lead up to AV fistula surgery. A particular concern

amongst 'LA/mixed dominant' centres was the additional time required to deliver blocks and, thus, efficient processes and good communication between surgical and anaesthesia teams will likely be paramount to the success of a future trial. Although qualitative research is useful for illuminating possible barriers to future clinical trial conduct, there is a possibility that actual barriers encountered may be different. It would, therefore, be useful to embed mixed methods research in such a trial from the beginning, to rapidly identify new barriers and respond to these to optimize recruitment. The QuinteT Recruitment Intervention [19] is one such approach, and has been applied to over 35 RCTs, with promising evidence of improving recruitment [20]. It entails rapid investigation of recruitment processes through mixed methods [21], to determine the real (rather than hypothetical) factors that compromise recruitment. These insights are then used to inform the design and delivery of strategies to overcome recruitment issues as the trial is underway.

We recognise that this study has a number of limitations. The survey methodology required only one anaesthetist to respond on behalf of a centre. Anaesthetists were approached and asked to consult colleagues and provide a consensus approach on behalf of their centre. This could mean the reporting is vulnerable to bias and may not fully represent the practice and views of all anaesthetists working in that centre. We did not interrogate the use of ultrasound or the practice around contraindications for RA blocks, as these practices are informed by recent guidelines from the Association of Anaesthetists and the European Society of Anaesthesia [22, 23]. A particular limitation of the qualitative research was the clustering of all surgical respondents from one LA/mixed centre, which limited the breadth of perceptions/experiences captured from this professional group's perspectives. Patients were not interviewed as part of this study. There is a possibility that patients' preconceptions and beliefs around mode of anaesthesia may serve as barriers to use of brachial plexus blocks. These should be explored and addressed in a future trial to support recruitment and informed decision making. A recent study from our group conducted detailed interviews with patients about mode of anaesthesia as an intervention and showed that patients are amenable to further prospective clinical research, particularly as an exploration of the effects of different modes of anaesthesia on patient outcomes after surgery may provide evidence-based guidance for clinical decision making [18].

In conclusion, we have shown that the use of brachial plexus blocks for AV fistula formation across multiple centres in the UK is varied and influenced by a multitude of factors and

that, despite the availability of anaesthetists capable in performing regional blocks, there are other limiting factors that influence the routine use of this technique.

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Supporting Information

Additional supporting information may be found online via the journal website.

Appendix S1 Survey questions.

Appendix S2 Interview topic guides.

Appendix S3 Themes and subthemes from thematic analysis with example quotations.

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¹Ehrenfeld et al. *J Blood Disorders Transf.* 2014; 5:9. ²Awada WN et al. *J Clin Monit Comput.* DOI 10.1007/s10877-015-9660-4. Study Protocol: In each group, if researchers noted SpHb trended downward below 10 g/dL, a red blood cell transfusion was started and continued until SpHb trended upward above 10 g/dL. The transfusion threshold of 10 g/dL was predetermined by the study protocol and may not be appropriate for all patients. Blood sampling was the same for the control and test group. Arterial blood was drawn from a 20 gauge radial artery cannula into 2 mL EDTA collection tubes, mixed and sent for analysis by a Coulter GEN-S Hematology Analyzer. ³Kamal A, et al. *Open J of Anesth.* 2016 Mar; 6, 13-19. ⁴Imaizumi et al. *Proceedings from the 16th World Congress of Anaesthesiologists* Hong Kong, Abstract #PR607. ⁵Cros et al. *J Clin Monit Comput.* Aug 2019; 1-9. Study utilised a goal-directed fluid therapy protocol with PVI in conjunction with a blood transfusion protocol based on SpHb. ⁶Ribed-Sánchez B, et al. *Sensors (Basel).* 2018 Apr 27;18(5). pii: E1367. Estimated national savings derived from hospital savings extrapolated nationwide. *Data on file.